measurements, details in IR imagery result from emissivity variations as well as thermal variations. Disturbing an item's surface texture creates an emissivity difference producing local changes in the infrared image. Identification is most accurate when IR images of unknown marks are compared to IR images of marks made by known tools. However, infrared analysis offers improvements even when only visual reference images are available. Comparing simultaneous infrared and visual images of an unknown item, such as bullet or shell casing, can detect illumination-induced artifacts in the visual image prior to searching the visual database, thereby reducing potential erroneous matches.

In the Specification:

A marked-up copy of the changes to selected paragraph(s) is provided below. A clean copy of these changes is provided in the attached separate sheet, entitled "Clean Version of Changes to Specification". Please replace the marked-up paragraph(s) with the replacement clean copy of the selected paragraph(s) attached hereto.

Add the following paragraph before page 1, line 1:

– This application for patent claims priority from U.S. Provisional Patent Application No. 60/087,512 filed June 10, 1998. –

Marked up paragraph at page 1, lines 28 to page 2, line 6, where a tab indent is inserted:

_____The shell casing receives marking from the firing pin hitting the primer, from the back pressure of the gas expansion forcing the casing against the breech face of

the firing pin housing which may have marks or defects which transfer onto the primer and/or casing. These marks may be a result of manufacturing defects, or hand finishing done in high quality weapons. Breech face marks can be compared just as can firing pin marks, either by firing a test round or by examining the weapon when the weapon is available, or by comparing corresponding marks on two bullets or casings which are suspected of coming from the same weapon. If the same weapon is used to fire the same type ammunition at the same type target from the same distance, comparable patterns will be produced on the bullet and casing. If the ammunition is changed, the patterns will be somewhat different.

Marked up paragraph at page 2, lines 11-19, where a tab indent is inserted:

______Class characteristic marks vary with calibre, load, material used for the bullet or shot, bullet weight, its impact behavior, material used for the casing, and identification stamped into the bullet and casing. Intentional marks on ammunition include information stamped on the face of the bullet casing during molding of the shells. Some casings and bullets also have an indented ring or rings around the circumference called a canellure. These are smeared with grease or wax as sealer, making the bullet water-resistant and providing some lubrication as it is forced through the barrel. The canellures on the casing are imprinted within a quarter inch from the top after the bullet is inserted. This crimp acts to seal the round and hold the bullet in the casing. Canellures may contain imprint information unique to the manufacturer and perhaps to a particular crimping tool.

Marked up paragraph at page 10, lines 15-16:

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Image sequence focus montage - [lso] also referred to as a montage - combined sharp focus portions of multiple images in a sequence to make one or more composite images

Marked up paragraph at page 12, lines 6-14:

The individual characteristics of the ammunition and weapon include the particular surface condition and shape of the bore, the particular striations imposed on the bullet, and the particular markings imposed on the casing. These characteristics can also be determined using infrared images. Even when caseless Teflon bullets are used, active infrared imaging may exploit minute markings transferred to the bullet by the barrel and firing charge. A rotating IR probe, similar to endoscopic cameras in medical use, can produce a detailed image of a gun barrel, which can then be matched against casings and [bluets] bullets which are suspected of having been fired from that gun. In some instances, this may be preferable to making test firings from the weapon; particularly if the weapon is considered unsafe, or if it is necessary to preserve the weapon in its present condition as to residue etc.

Marked up paragraph at page 12, lines 28-30:

Heat conduction analyses can be performed by heating the ballistic item and imaging it while it cools. Estimates of the depth and volume of indentations, striations, and gouges can be made based on their cooling rates. The material [compostion] composition of each area of the item must be considered.

Marked up paragraph at page 13, lines 4-16:

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Current systems, such as DrugFire, compare an unknown ballistic item's image to all corresponding images in a database, producing a correlation value for each. Database images are then re-ordered based upon that correlation value, with the highest correlation ranked first. In controlled testing where the identities of all siblings are known, a measure of the accuracy and efficiency of the matching engine is the position of siblings in the re-ordering. The results shown below in the left column are taken from the DrugFire system manufactured by Mnemonics Systems [Inc.] Inc.. The right column shows the use of a different matching engine (FlashCorrelation® patented by the inventor) with the same visual image database as used by Mnemonics. 1157 shell casings from 229 weapons were used for the tests. The images were all taken with a conventional videomicroscope camera. MIKOS did not have the opportunity to collect its own images of the casings. Therefore, no infrared images were obtained or used for this comparison test. The purpose of this table is merely to show how ballistic matching systems are evaluated. In a smaller test, the use of infrared imagery produced significant additional improvement in position of siblings over the use of visual imagery, with nearly all siblings clustered at the very top of the ranking.

Marked up paragraph at page 16, lines 19-27:

Selection of features to be characterized, and the characterization process, can be fully automated or manually assisted. Partitioning significantly reduces the search time required to look for matches, but requires knowledge about the variations which may occur in firings of a particular weapon. For example, changing the ammunition size or type used will change the markings imposed by the weapon. Therefore, in conducting a search against a database, to reduce the occurrence of false negative results, the criteria for including a database item as a candidate matching item must be

considered relative to possible variations such as: whether the weapon has [interchangable] interchangeable barrels, whether it might be used with different sized ammunition, whether it might have been cleaned, whether it might have had heavy use between the database entry and the current characterization.

Marked up paragraph at page 18, lines 19-22:

Images in the casing sides and bullet databases should be formed as composites of the multiple frames taken as the bullet or casing is rotated. The composite images can be oriented [soas] so as to align striations with the horizontal plane of the image. Due to spiraling of the lands and grooves, image segments must be composed to create an image of the resulting striation pattern from the various segments imaged.

Marked up paragraph at page 23, lines 1-10:

Figures 1a, 1b, and 1c are visible images of the primer areas of sibling casings. The image illustrate the effects of illumination variations and artifacts. In particular, the firing pin indentations in the centers lack any details, and each shows glint from the illumination. Each image is oriented based upon the breech face marks and the position of the firing pin indentation. 1a has the best detailed primer area. The illumination of 1b causes much of the breech face markings to be lost., and reverses the appearance of the feature at 10:00 from a white to a dark line inside a grey area. The firing pin indent also appears smaller than in a. In c, a slight variation in the illumination angle make the firing pin indentation appear to be raised up instead. Turning the image [upsidedown] upside down makes it appear to be an indentation; however then the [posiition] position of the indentation is incorrect. Depending on

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the match engine, these siblings may not be detected as matches based upon these visible images due to the illumination-induced variations.

Marked up paragraphs at page 23, lines 20-23:

Figure 6 is an infrared image of a shell casing at ambient temperature, with focus set for a [distinctinve] distinctive tool mark.

Figure 7 is an infrared image of a shell casing at ambient temperature, with focus set for a [distinctinbe] distinctive tool mark in the primer area.

Marked up paragraph at page 23, lines 29-30:

Figure 11 a,b,c illustrates the removal of the manufacturers markings from the casing image prior to matching.

Marked up paragraph at page 24, lines 24-25:

A controlled light source 110 is then turned on to illuminate the [balistic] ballistic item and a video camera 116 is used to produce a sequence of visible images 120 by varying the focus mechanism [18] 118.

Marked up paragraph at page 24, line 26 to page 25, line 4:

Each image is annotated with date and time, workstation #, item temperature, focus setting, and item reference number. The focus and image capture processes can be automated such that a succession of minute variations in focus is performed and an image taken at each step, or the focus and image capture can be manually controlled

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using an examiners workstation consisting of a display screen 22 and input controls 24 including any combination of keyboard, mouse, voice, or similar device. The workstation also contains highlighting device 90 for manually specifying areas of images or textual information of particular interest to the examiner. The highlighter can be any combination of touch screen, lightpen, graphics tablet, or similar device. The display has the ability to mosaic several infrared [22] <u>20</u> and visible [122] <u>120</u> images on a single screen.

Marked up paragraph at page 25, lines 5-9:

Text information is entered which identifies the ballistics item and related information such as case #, weapon type, ammunition type, location where found, etc. That information can be read from an evidence tag using a bar code reader 28 or input through the controls of the examiners workstation such as by keyboard. The text information can be displayed on the screen 22 along with the corresponding [annnotated] <u>annotated</u> image.

Marked up paragraph at page 26, lines 9-13:

The resulting montaged infrared and visible images, along with their characteristics and textual [infromation] <u>information</u> are entered into a database of infrared characterizations 50 and enhanced visible characterizations 150 of unknown [balistic] <u>ballistic</u> items. The enhanced visible characterization can then be used with current ballistic identification methods and apparatus, producing more accurate results due to the [elimnation] <u>elimination</u> of illumination-induced artifacts, and the detection of hidden features due to shadow.

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Marked up paragraph at page 27, lines 7-11:

Text information is entered which identifies the ballistics item and related information such as case #, weapon type, ammunition type, location where found, etc. That information can be read from an evidence tag using a bar code reader 28 or input through the controls of the examiners workstation such as by keyboard. The text information can be displayed on the screen 22 along with the corresponding [annnotated] annotated image.

Marked up paragraph at page 27, lines 15-18:

The sequences of [infrarred] infrared images are processed to extract and characterize apparent features at 42 using any of various standard automated image processing techniques or by manual highlighting by the examiner. Characterization at a minimum includes the relative positions of features, their shape, their area and perimeter length, and variation in gray scale distribution within the feature

Marked up paragraphs at page 28, lines 6-19:

Database 60 will contain characterization of known or linked [balistic] ballistic items. When an unknown item 10 is presented for identification, it is processed as detailed above to produce its characterization at 50. The resulting characteristics are used to select initial candidates from the database 60 based upon text, image, and feature characteristics which are relatively immune to error or variation. For example, the calibre of ammunition. In matching shell casings, if the unknown firing pin indentation is centered, only database entries with centered firing

pins are considered as potential candidates. The presence or breech face markings, ejector or extractor marks may also be considered relatively immune to error or variation.

The initial candidate matches are then further processed using the text matching engine 70 which might provide for example the date of manufacture of the weapon, meaning that all ballistic items collected prior to that date need not be considered as matches. Other information is compared and scored as to similarity, such as information about the type of crime associated with the [balistics] ballistics item, the locale where the item was collected, the presence of other similar items at the same collection, etc. The similarity score will generally not exclude candidates from further consideration, but may influence their rank ordering in presentation to a ballistics examiner for consideration below.

Marked up paragraphs at page 28, lines 20-28:

Remaining candidate matches are then further processed using the feature matching engine 72 which first compares summary characteristics such as the number and type of features, and then compares the details of each feature of the unknown and candidate items. Various metrics or scoring techniques can be defined to calculate a goodness of match based upon the feature characteristics. Fingerprint matching and face matching technique are especially suitable, with Prokoski et. al U.S. Patent [____________.] No. 5,163,094 as an example. Candidates which do not correlate sufficiently with the unknown item are not longer considered.

Remaining candidate matches are then further processed by correlating the montaged images using an image processing technique such as Prokoski U.S. Patent [____________] No. 6,173,068 to produce an image correlation value. Other image processing comparison techniques may be used.

Marked up paragraphs at page 37, lines 1-20:

[REFERENCES

Provisional Patent Application, Method and Apparatus for alignment, comparison, and identification of characteristic tool marks, including ballistic signatures, Application ______________________ F. J. Prokoski, date _______.

National Institute of Justice symposium, Orlando Florida, ___________ 1999, Office of Law Enforcement Technology Commercialization, handout and demonstration. Handout titled:
IRID- Ballistics; Infrared Identification of Shell Casings and Bullets.

Tsuneo Uchiyama, National Research Institute of Police Science, Tokyo, Japan, " A Criterion for Land Mark Identification", AFTE Journal Vol 20, Number 3, July 1988, pp 236-246

Tsuneo Uchiyama, National Research Institute of Police Science, Tokyo, Japan, " A Criterion for Land Mark Identification Using Rare Marks", AFTE Journal Vol 20, Number 3, July 1988, pp 260-264.

Tsuneo Uchiyama, National Research Institute of Police Science, Tokyo, Japan, " Automatic Comparison Model of Land Marks", AFTE Journal Vol 20, Number 3, July 1988, pp 250-259.

Baldur et al., US Patent 5,390,108, Feb 14 1995, Computer Automated Bullet Analysis Apparatus.]

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